EXPLORING THE POTENTIAL OF CLOUD COMPUTING FOR MOBILE SYSTEMS: CHALLENGES AND OPPORTUNITIES

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ABSTRACT

Through the provision of application services via the Internet and the promise of more outstanding processing capabilities for mobile devices, cloud computing promises a tremendous improvement in computing. Although cloud computing has the potential to provide access to parallel data processing and decrease energy consumption, the practicality of this technology for use in actual mobile applications is still debatable. This research details a system for safely sending information and calculations to unreliable commodity clouds. This strategy aims to maximize the advantages of cloud computing while also addressing computer security concerns. Our method separates security-critical jobs to dependable clouds and processes encrypted data concurrently on fast commodity clouds to maximize performance and security.

While cloud computing seems very promising, some issues still need to be resolved before mobile apps can fully utilize it. The research team behind this project set out to define mobile Cloud computing and evaluate its many varieties. This is achieved by doing a literature study on mobile computing within the context of different cloud computing ideas. We summarise the difficulties encountered in this field of research and provide some suggestions for utilizing mobile cloud computing to create mobile applications with more impact.

There are several benefits to having a computer in the cloud, including increased flexibility, additional storage space, and reduced expenses. It could use the Internet to transfer computing resources. Although surveys indicate that moving computing to the cloud has many advantages, there are particular difficulties when combining cloud computing with mobile devices. Mobile computing must consider the limited energy and wireless bandwidth available when integrating cloud services. However, if these problems are fixed, cloud computing may provide mobile consumers with better performance and energy savings.

KEYWORDS: Cloud Computing, Mobile Computing, Remote Execution, Distributed Systems, Automatic Offloading

HOW TO CITE THIS ARTICLE:
Maitri Rajesh Gandhi (2021). Exploring the Potential of Cloud Computing for Mobile Systems: Challenges and Opportunities, International Educational Journal of Science and Engineering (IEJSE), Vol: 4, Issue: 1, 01-07

Research Paper

INTRODUCTION

The proliferation of in-built sensors and the improved data-sharing capabilities of mobile devices allow users to run complex apps on these devices. This paves the way for easy integration of mobile apps with web 2.0 services and real-time data sources. Here are a few examples of these applications: mashups, open collaboration, social networking, and mobile commerce [1, 2]. Every day, more and more jobs go via the mobile execution platform. Things like playing games, recording, editing, annotating, and uploading videos, managing finances and health, making micropayments, buying tickets, and engaging with pervasive computer infrastructures are all examples of what we mean. Mobile devices will perpetually lack resources, security, consistency in connectivity, and efficiency due to their reliance on batteries. Mobile devices will remain inherently insecure even while mobile network capabilities and device technologies are constantly improving. A lack of resources is a big problem for many applications [3].

For this reason, there is almost no way to make a compromise while utilizing mobile devices for computing. One way of looking at mobile devices is as portals via which internet services hosted in the cloud may be accessed. The precise definition of “cloud computing” has been the subject of recent discussion. Many people have the wrong idea about what the cloud computing paradigm can do. This word describes nearly any form of outsourcing hosting and computer resources. Cloud computing is a paradigm that allows users to effortlessly and instantaneously access computer resources over the network. Minimal administrative labour is required to release and supply these resources quickly. With the advent of new technologies like mobile Web, location-based services, wireless communication infrastructure, and portable computing devices, a new paradigm called mobile cloud computing emerged. This model makes the amount of processing and storage space available to users online infinite. We refer to "mobile cloud computing" as "a model for transparent elastic augmentation of mobile device capabilities via ubiquitous wireless access to cloud storage and computing resources, with context-aware dynamic offloading adjustment in respect to change in operating conditions, while preserving available sensing and interactivity capabilities of mobile devices." The characteristics of cloud computing of mobile devices led to this explanation."

LITERATURE REVIEW

Several prominent mobile cloud options have been discussed in this post. This essay aims to provide a general outline of the many options for mobile cloud computing. There are a lot of other works that are pretty relevant to this topic. None of the existing methods cover the bases regarding mobile cloud requirements. You may classify mobile apps as "web apps" that run on the Internet or "native apps" that run locally on the user's device. The prior kind uses mobile device capabilities, but the interface with the cloud is somewhat primary. In addition to interface problems, the second category is characterized by inefficient utilization of the processing power and sensors of the mobile device.

Consequently, we think that mobile cloud apps' full potential is somewhere in the middle, where the duties are constantly being switched between the cloud and mobile devices simultaneously. Many researchers have demonstrated methods that accomplish this goal, such as decoupling certain program parts or making a complete copy of the device's software. Offloading can occur on distant data centres, local computers, clusters of adjacent computers, or mobile devices. A cost model also has to consider many other aspects, as mobile settings are notoriously unpredictable. Additionally, rapid predictive optimization methods ascertain the optimal program execution. It is necessary to have an efficient and realistic programming abstraction to make development easier. Mobile cloud computing presents complex research challenges that the area of information and communication technology will encounter for the foreseeable future. To tackle this challenge, additional investigation into systems, networks, and human-computer interaction is required.

Regarding processing power and network architecture, the cloud is rock solid. A thin and broad network, also called "self-healing," may gently recover from typical problems like hardware and connection failures since many drones are available to do the job. Additionally, a large amount of electricity may be required for a cloud's operation. Not only does it need much electricity to run the thousands upon thousands of central processing units (CPUs) and other components like cooling fans and hard drives, but these constantly rotating gadgets also produce much heat. Virtualization is being used widely by data centres to reduce power costs and maximize wattage use. With virtualization, running many operating systems on a single server is possible. Citrix, which recently bought the Xen virtualization technology, and VMware are just two examples of large manufacturers focusing on the data centre, making this an increasingly important issue. The time the CPU spends idle is minimized when every operating system is sandboxed behind artificial boundaries, and each instance may operate independently of the others. The difference between "a bunch of machines" and a "cloud" isn't always noticeable. However, there may be less muddle, thanks to the "data centre operating system" (often dubbed CloudOS to keep with the hype).

Several scholars have pointed out the main issues with mobile computing [10, 12]. Characteristics of mobile computing environments include severe resource constraints and frequent job context changes. For now, we may expect mobile devices to have limited capabilities in terms of processor speed, memory, screen size, and input types. Several ideas for mobile applications have their roots in this.

Offline Applications:

This encompasses the vast majority of applications available for modern mobile devices. The mobile devices act as a fat client, executing the display and business logic layers locally utilizing data obtained from backend services.

SAVING ENERGY FOR MOBILE SYSTEMS

Many users now primarily use mobile computing platforms, such as smartphones. According to many studies, the most essential aspect of these gadgets is a longer battery life. Users in fifteen different nations ranked extended battery life higher than any other feature, including storage and cameras, in a 2005 survey. A study conducted by ChangeWave Research last year found that the short battery life of the iPhone 3GS was the feature users disliked the most about the device. Conversely, the most common gripe with music phones was their battery life, according to a 2009 study by Nokia. For many apps, the minimum required processing power on a mobile device is ridiculously high. Such apps can't be helpful for mobile users unless the calculations are done on the cloud. You may use a mobile device to access many other programs, including ones that do image retrieval, speech recognition, gaming, and navigation. However, the quantity of energy consumed is significantly higher due to them. Could mobile device users extend their battery life and decrease energy usage by transferring these programs to the cloud?

The client and the server-side software are periodically synced with one another. "fat client" refers to a networked program that extensively uses local resources. In contrast, a thin client uses a network to spread its resources. Background applications, sometimes called native apps, provide:

- Good access to the functions of the gadget and good integration with its functioning
- Performance enhanced for multitasking and particular hardware
- Constantly accessible features, even in the absence of network connectivity. However, there are some drawbacks to native applications:
- Lack of platform mobility

- intricate code
- lengthier time to market
- a prerequisite for learning new programming languages among developers.

Online Applications: A connection between mobile devices and backend systems is usually expected when an online application is available. Smartphones' strength and effectiveness in apps are mainly responsible for their popularity. However, the devices aren't without flaws, such as problems with cross-platform compatibility. As an alternative to native apps, web-based ones are fantastic. In such a situation, web technologies may shine. Mobile apps can solve some of the problems with offline apps since they are more portable:

- cross-platform and instantly available from any location
- Developers have a broad understanding of Web technologies, significantly reducing the learning curve needed to develop mobile applications.
- However, there are drawbacks to mobile Web applications:
- Excessive delay introduced for real-time responsiveness; interaction performance is impacted by even 30 msec of latency
- Lack of access to the device's functions, such as the camera or motion detection, creates challenges in managing intricate situations that call for prolonged conversation sessions.

Issues with Offline and Online Mobile Applications: Since programs are statically partitioned nowadays, most program execution happens on the device or backend services. There may be large swings and unexpected changes in the state of the network and the availability of local resources when mobile clients try to access data and services elsewhere. Therefore, many different kinds of applications and devices cannot be accommodated by a single partitioning paradigm. For systems and applications to work in these ever-changing settings, mobile cloud apps must be flexible enough to adapt their computational power between the cloud and the user's device on the fly. Put another way, computations in the cloud and by consumers must be flexible enough to accommodate changes in mobile contexts. [13].

PROBLEM FORMULATION

Augmented Execution

To fix problems with memory, processing speed, and battery life in smartphones, the phrase "augmented execution" is employed. The design put out by Chun and Maniatis [14] is shown in Figure 1. Adapted from [14], the Clone Cloud categories for enhanced execution address these issues. To do this, the task of program execution is moved to the cloud computing infrastructure, where a duplicated smartphone app executes. Apps that need a lot of RAM and CPU power are typically stored on mobile phones. However, the cloned system image of a device is executed in the cloud, which handles part or all of the responsibilities. After the enhanced execution, the results are reincorporated into the final product. To offload massive computations, this method uses virtualized or simulated cloud-based clones of the mobile device that are only loosely synced. A taxonomy of the many possible mobile-based enhanced executions is also presented in Figure 1. There are five distinct types of outsourcing. Here are the five parts that make up a virtual machine: (1) hardware, which is the copy running on a more potent emulated virtual machine; (2) mainline, which is somewhere in the middle; (3) multiplicity, which is helpful for parallel executions; and (4) primary functionality outsourcing, which is more like a client-server application. Satyanarayanan et al. [3] outlined a similar approach to operate computationally heavy applications on a mobile device through virtual machine (VM) technology.

Table Of Service provider outages[22,23]

Outage date	Vendor	Service
July 2008	Amazon	S3 outage
Feb 2008	Amazon	S3 outage
August 2008	Google	Gmail service outage
October 2009	T-Mobile/Microsoft	Sidekick loses users' data

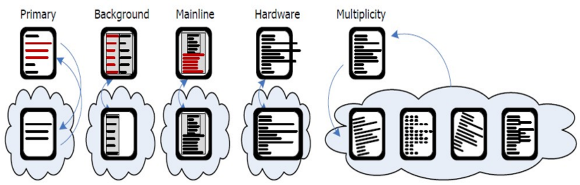


Fig. 1. Clone Cloud categories for augmented execution (adapted from [14])

With virtual machines (VMs), a user on the go may quickly launch their service app on a nearby cloudlet and then connect to it using a wireless local area network (WLAN). Cloudlets are collections of dependable online computers accessible to mobile devices in the vicinity. These computers either have enough resources or are linked to the Internet. When accessing resources in the cloud, cloudlets do away with the sluggishness caused by WANs. This is accomplished by utilizing a distant cloud. This indicates that a high-bandwidth, one-hop, low-latency wireless connection to the cloudlet enhances the device's responsiveness and engagement. The mobile client is a thin client, with all the critical computing happening in a nearby cloudlet. See Figure 2 to illustrate how this tactic employs dynamic virtual machine creation.

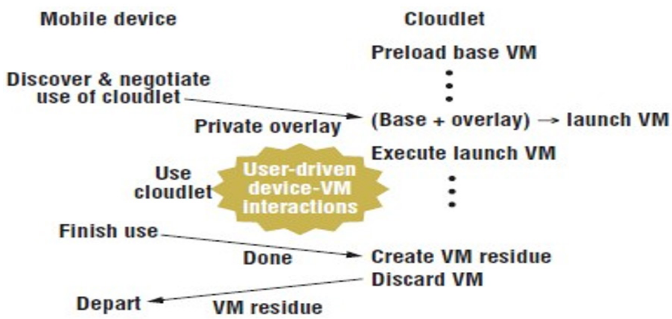


Fig. 2. Dynamic virtual machine synthesis timeline (adapted from [3])

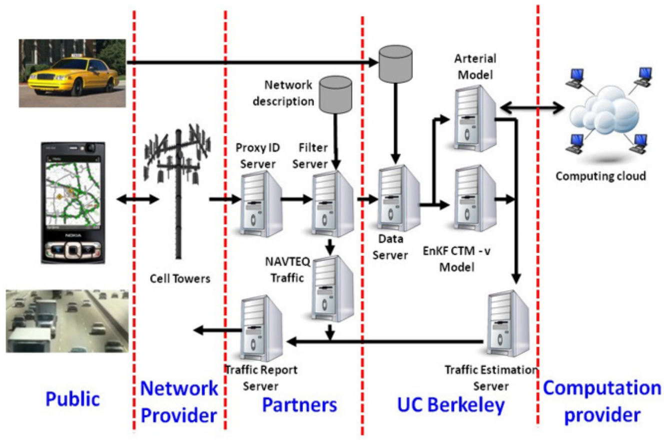


Fig.3. Schematic architecture of the Mobile system

The mobile device is responsible for delivering the cloudlet infrastructure with mini virtual machines (VMs) overlays; the cloudlet infrastructure already owns the underlying VM from which the VMs were formed. The infrastructure creates the virtual machine (VM) by applying the overlay on the base; the VM resumes its previous state upon startup. Still, according to Satyanarayanan et al. [3], the timetable for creating DVMs is shown in Figure 2 (adapted from [3]). The sixty to ninety seconds required for virtual machines (VMs) to synthesize can make it impossible to do basic or ad hoc operations in that time. Garriss et al. [15] employ a comparable idea to build a trustworthy and customized computer system. Here, the premise is that people may run their virtual machines (VMs) in public kiosks. Customers use their own mobile devices to establish a level of confidence with kiosks before really utilizing them. Users may restore their desktop, complete with their preferred OS, apps, settings, and data, using virtual machines (VMs).

Elastic Partitioned/Modularized Applications

To operate applications successfully in environments with heterogeneous changes, such as mobile clouds, some program components must be executed remotely, and programs must be divided dynamically. Applications that allocate a part of their software to be run remotely on a cloud infrastructure with lots of resources might potentially run more efficiently.

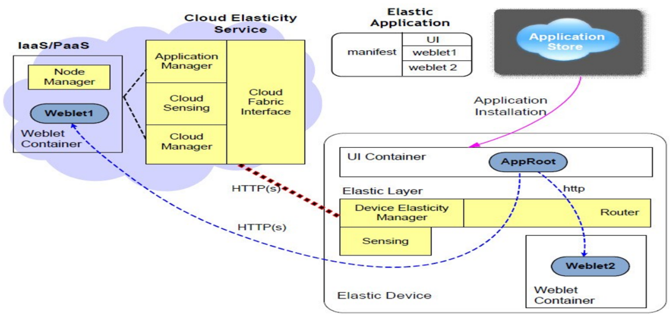


Fig. 4. Reference architecture for elastic applications (adapted from [20])

Application Mobility

The mobile cloud is accessible from a wide variety of devices. The same apps need to work on several devices for the user experience to be seamless. The application's mobility is vital for the next generation of mobile apps to be possible. Application mobility refers to transferring an application from one host to another while running. Moving open applications from one device to another so the user may use them immediately is the most basic definition of application mobility [13]. Process migration is closely associated with the concept of application mobility. An operating system feature called process migration enables the resumption of a running process on a different machine after it has been moved. Task transfer to various architectures and user interface modification are also part of application mobility, encompassing more than process movement. One more thing: It's platform-specific so it won't work on other systems with too high latency.

Ad-hoc Mobile Clouds

By using ad hoc computing, "cloud" refers to a network of interconnected mobile devices that perform collective computing tasks on behalf of other users. This form of mobile cloud computing becomes more appealing in places where big cloud providers are inaccessible or have spotty Internet service. By transferring data to nearby mobile devices, you may avoid charging your smartphone, saving money. When you are on the road, this will come in handy more than anything else. One further perk is that it makes it easy to form virtual communities where people may work together on projects.

Comparison of Mobile Cloud Application Models

A comparative analysis of the various technologies now being utilized for mobile cloud computing may result in developing a more efficient mobile application solution. As mentioned earlier, the application models can achieve the objective of applying cloud computing to mobile devices on various scales.

To compare the models, we utilized the following criteria:

- The technology that lies behind the surface and makes it possible to accomplish the desired characteristics of a system is referred to as middleware.
- Concerning the cost model, do the numerous aspects of mobile clouds receive optimum performance? In the first place, go to Hadoop.apache.org.
- In programming, abstraction refers to how powerful the programming tools are utilized to construct applications in a more efficient and speedy manner while still preserving control over a variety of mobile cloud technologies.
- The generality of the solution refers to whether or not it applies to all applications or only a few types of applications.
- Implementation Difficulty: How difficult is developing cloud applications compatible with mobile devices?
- What are the differences between static and dynamic adaptation, and how do mobile clients and the cloud differ in their roles?

PROPOSED METHODOLOGY

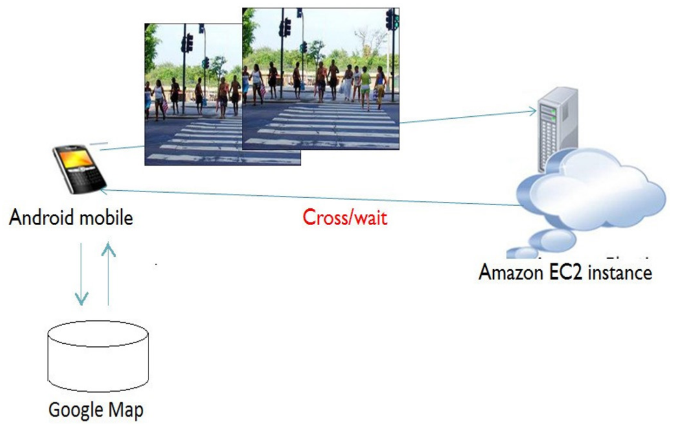
Programming Abstraction

There has to be an easy process for creating apps for mobile clouds. Furthermore, the developer needs to have complete control over the placement and behaviour of his software. To fully utilize the advanced mobile devices and cloud computing resources at our disposal, we need to create new methods of programming abstraction that can mask the underlying cloud technology's complexity. The developed software modules must be compatible with various mobile device hardware specifications. Map Reduce is a framework that allows task processing on thousands of computers at once; the programming tools should also be able to develop cloud programs in a style that facilitates scalability. A complete app for the cloud, middleware, and mobile client should be able to be designed with the help of the programming tools. This app should allow dynamic storage and computation shifting among these three parts. They built an SDK that controls the lifespan of application modules and will enable users to construct their fundamental interfaces, using Zhang et al. [20] as an example. Software developers may use the SDK to build apps in languages like C# and Java, considered high-level. It is advantageous to think about new applications and services and the possibility of migrating current apps and services to cloud infrastructure to promote the growth of mobile clouds.

Cost Model To transfer computations between mobile devices and the cloud in real time, it was necessary to decompose programs into interconnected modules. The cost model describes several metric criteria used to dynamically generate the modules on mobile devices and then transfer them between mobile devices and the cloud. A module's runtime, resource consumption, battery life, price, security level, and network bandwidth are all characteristics that could be considered. A critical component is the time a user has to wait after doing certain actions on the device's interface before they get the desired output or exception. The time consumers wait is essential to consider when choosing between local and distant data processing.

Adaptation

Mobility requires adaptability. The variety of application and system adaption options is listed in [10]. Two extremes define the range. At one extreme, each particular application is solely responsible for its adaptation.

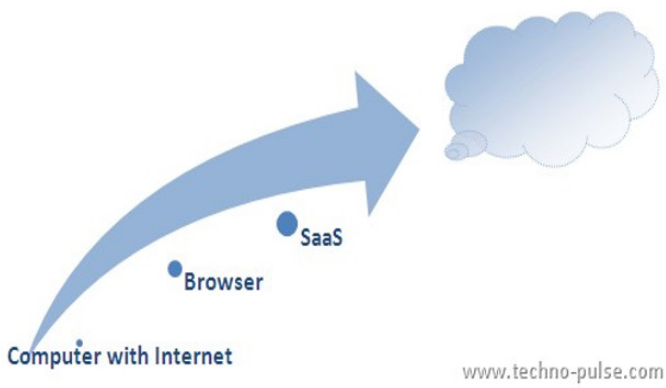


"Fig.5. Data Access through Cloud with Android Mobile"

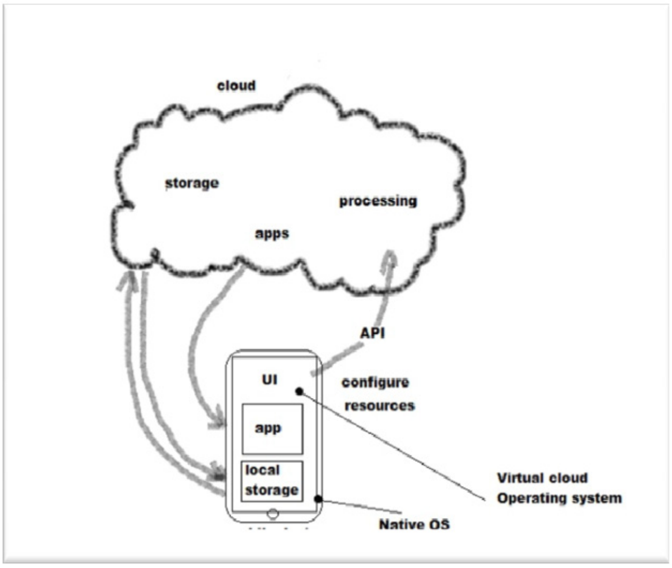
Cloud Integration Cloud storage is among mobile applications' most apparent examples of cloud computing. When storing data, apps, operating systems, and multimedia, the storage space of most smartphones is somewhat restricted. Data transfer size optimization refers to the maximum amount of data sent in a single transmission. Due to the very variable bandwidth of mobile apps, the data transfer mechanism should ideally additionally include some level of parameterization to handle scaling the chunk size proportionate to network capacity. This is because chunk sizes are modifiable. To conduct operations in a continuous process, data must be readily available. Data persistence is keeping data in the cloud until it is needed again. It is evident that there is a trade-off between them and that the network connection, bandwidth, device capacity, and latency are all important factors to consider. While there are ways to benefit from caching, using cache on remote databases requires extra work, including verifying cache coherency. Cross-platform execution and migration are currently limited in their availability, which is a need for mobile cloud computing systems. All of the above-discussed approaches are essentially related to a single middleware. However, as a primary problem, the mobility between cloud formations has not yet received enough backing.

Trust, Security and Privacy

In cloud computing, there will always be questions about security concerning multi-tenancy, concurrency, scalability, and distribution. Many factors can cause immediate worries, like the fact that dispersed infrastructures make it difficult to regulate the flow of data and code, the risk of data corruption, and so on.



"Fig.6. Software as a Service"



"Fig.7. Mobile cloud Approach with parallel storage

FUTURE OF MOBILE COMPUTING

1. Devices will integrate each other's technology. Examples:
   - PDA Cell Phone
   - Cell Phones working with WLAN's
   - Cell Phones with MP3 players

2. Wired devices are a thing of the past
   - Landlines

3. Android app development"

"RESULT & DISCUSSION

Storage and space are crucial and incredibly critical when it comes to computers. The size of the hard drive is an essential consideration for consumers when purchasing computers; the more significant the hard drive, the better. Currently, hybrid PCs are available with solid-state and cloud drives with finite storage space. For instance, netbooks such as the ASUS Eee PCs have a 250 GB hard drive as standard, and they also provide 500 gigabytes of extra storage space through their "ASUS Web Storage" service. Organizations may store data and information by utilizing the servers and databases that the cloud computing provider offers. This has significant implications for two main reasons. First, because businesses can get rid of big, space-consuming servers, it lowers their costs. A company will eventually need to buy more servers to accommodate the growing amount of data it collects since it is most likely infinite. Because cloud networks enable organizations to store data indefinitely, they can store an endless amount of data from the cloud drive. Cloud computing offers the processing power and storage capacity needed to handle such massive volumes of data efficiently. Cloud computing effectively reduces the friction that comes with the difficulties of handling vast volumes of data. Unlike Amazon, this eliminates the chance of underutilization because payment is only given for actual use. This is one instance of a subscription service. Subscription services are also beneficial since, when businesses purchase software, they lose money because the package they paid for at the total price becomes outdated when it is updated. For this very reason, subscription services are beneficial. Businesses can save money on both the cost of operating the servers and the maintenance costs associated with them because they are not required to keep large servers on their property. Additional costs involved with this include those related to paying engineers and personnel to set up and maintain these databases. Many companies, like Samsung and Acer, are already creating products that are entirely cloud-based in nature. "Laptop manufacturing companies have created Chromebook" machines. These laptop computers only have the Google Chrome browser installed. The Samsung battery has a longer lifespan (up to 8.5 hours) because there is no hard drive.

Furthermore, no payments are due to Microsoft because there are no serial numbers or copyright protection. These are a few benefits of this design. The Chromebook's quick 10-second startup time is a significant benefit. There is no need to worry about losing sensitive and priceless files if a Chromebook is stolen because data are kept on the cloud. Users may log onto whatever Chromebook they choose to access their personal information. Chromebooks are more reasonably priced than most laptops with reasonable prices. Likely, Chromebooks aren't helpful right now. However, after a few years of development and production by Google, they will prove effective and worth the price.

One of this era's most enormous technological advances is cloud computing, which is essential for organizations because of its range of functions. This computing style is highly flexible because of its many integrated services, enhanced data storage reliability, app collaboration, portability (which allows users to access data from anywhere), and devices that require less technology. Using the Cloud storage controller, it is feasible to make backups of the expanded, infinite storage space. Businesses can do away with the need for large servers and databases, which take up space and are costly to buy, set up, and maintain because the cloud is primarily automated. Furthermore, the obligation to purchase the software and the necessity of manually updating the program eliminate any need to worry about the servers malfunctioning. Not to mention, because everything is offered on a subscription basis and there is no requirement for unnecessary maintenance, software purchases, or updates, there is a notable decrease in costs. Government organizations and computers have benefited from cloud computing due to reduced costs and fees; nevertheless, it will be interesting to see what changes and improvements the Cloud program will have in a few years."

CONCLUSION

Several prominent mobile cloud options have been discussed in this post. This essay aims to provide a general outline of the many options for mobile cloud computing. There are a lot of other works that are pretty relevant to this topic. None of the existing methods cover the bases regarding mobile cloud requirements. You may classify mobile apps as "web apps" that run on the Internet or "native apps" that run locally on the user's device. The prior kind uses mobile device capabilities, but the interface with the cloud is somewhat primary. In addition to interface problems, the second category is characterized by inefficient utilization of the processing power and sensors of the mobile device. This leads us to conclude that mobile cloud apps' full potential is not on either end of the spectrum but instead in the middle, with the roles of mobile devices and the cloud constantly changing.

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